

Controlled Source Study of the Structure of the Seattle and Tacoma Basins – SHIPS99 (Seismic Hazards Investigations of Puget Sound): Collaborative Research with U.S. Geological Survey, Oregon State Un., and Un. of Texas at El Paso

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Introduction

The heavily populated Puget Basin is underlain by thick sequences of Cenozoic sedimentary rocks that amplify and focus seismic energy, thus increasing ground shaking during an earthquake. The SHIPS (Seismic Hazards Investigations of Puget Sound) project is targeted at acquiring and analysing controlled-source seismic data to be used in modeling and mapping areas of expected strong ground shaking and at better determining the regional velocity structure and tectonic framework of the Puget Sound region, including the location, configuration, and seismic properties of faults that cross this urban region. The first phase of SHIPS was conducted during March, 1998, and involved acquisition of marine multichannel seismic data, expanding spread profiles, and ocean-bottom on onshore/offshore large-aperture recording of marine airgun shots. This project represents the second, onshore stage of SHIPS, which was designed to acquire high-resolution data along an east-west transect through the Seattle metropolitan region. Surveying and permitting of 1000 stations and 38 shot points took the better part of the spring 1999, and was conducted by 5 individuals, 3 of whom were OSU employees. The actual deployment, originally planned for May, 1999, was conducted during September, 1999, and was very successful. During FY2000, we have been incorporating constraints from this experiment into our model of the structure of the subducted plate beneath the Straits of Juan de Fuca and Olympic Peninsula obtained from limited observations of secondary reflections while collaborators at UTEP and USGS have been focussing on modeling the first arrivals and on using the data to determine local site response.

Experiment

The SHIPS99 seismic profile was acquired in September, 1999, and is approximately 112 km long, extending from the Olympic mountains, through the city of Seattle, and into the Cascade foothills. Five different types of instrument were used, for a combined total of nearly 1000 receivers. Sources were 38 shots spaced ~ 4 km apart and ranging in size from 25 to 2800 lb. In addition, the magnitude 7.6 Chi-Chi earthquake in Taiwan occurred during the deployment, providing a unique data set on the high-frequency response of the Puget Basin to teleseismic events.

Results:

Data from the different instrument types were merged with GPS shot and receiver locations and offsets to generate SEG-Y format receiver gathers for each shot by Tom Pratt (USGS) and Leiph Preston and distributed to all. The data are of excellent quality. A number of the shots in the Seattle region provided surprisingly good signal to noise ratios. Secondary arrivals interpreted as wide-angle reflections from the lower crust and Moho are observed on a few shots. These are being incorporated into the SHIP98 dataset in order to image the structure and reflectivity of the subducting plate and plate interface (see annual report for project 1434HQ98GR00041).

Publications resulting from this project:

An article summarizing preliminary results and discussing the challenges of surveying and permitting 1000 station locations through a heavily populated urban area is currently in press (Brocher et al., in press). A second article on the site response of selected 3-component stations to the seismic waves generated by both the shots and the Chi-Chi earthquake will shortly be submitted. Numerous abstracts based on these data have also been presented at various professional meetings.

Brocher, T.M., T.L. Pratt, K.C. Miller, A.M. Trehu, C.M. Snelson, C.S. Weaver, K.C. Creager, R.S. Crosson, U. ten Brink, M.G. Alvarez, S.H. Harder, I. Asudeh, 2000, Report for explosion and earthquake data acquired in the 1999 Seismic Hazards Investigation in Puget Sound (SHIPS), Washington, U.S. Geological Survey Open-File Report 00-318, 85 p.

Brocher, T.M., T.L. Pratt, C.S. Weaver, A.D. Frankel, A.M. Trehu, C.M. Snelson, K.C. Miller, S.H. Harder, U. ten Brink, K.C. Creager, R.S. Crosson, Urban seismic experiments in Seattle, WA, investigate the Seattle fault and Seattle basin, in press, EOS.

Pratt, T., C. Weaver, K. T. Brocher, T. Parsons, M. Fisher, K. Creager, R. Crosson, R. Hyndman, G. Spence, A. Trehu, K. Miller, U. ten Brink, Understanding the seismotectonics of the Cascadia subduction zone: overview and recent work, in press, proceedings of the Conference on Seismotectonics of Subduction Zones.

Pratt, T.L., T. Brocher, C.S. Weaver, K.C. Miller, A.M. Trehu, K.C. Creager, R.S. Crosson, Amplification of seismic waves by the Seattle basin, to be submitted to Science.

Non-technical summary:

The heavily populated Puget Basin is underlain by thick sequences of Cenozoic sedimentary rocks that amplify and focus seismic energy, thus increasing ground shaking during an earthquake. The SHIPS 1999 seismic profile, extending from the Olympic Mountains, across Seattle and into the Cascade foothills, was designed to complement the SHIPS 1998 experiment by increasing the resolution of the models in this area. We have been incorporating constraints from this experiment into our model of the structure of the subducted plate beneath the Straits of Juan de Fuca and Olympic Peninsula obtained from limited observations of secondary reflections while collaborators at UTEP and USGS have been focussing on modeling the first arrivals and on using the data to determine local site response.